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Integration of virtual reality fire drill application into authentic learning environments

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Abstract

In this study, a virtual reality (VR) fire drill application was developed with head-mounted display VR technology for university students. The aim of the study is to evaluate the integration process of this VR application into authentic learning environments in terms of student opinions. Case study methodology was used in the study. The results show that this technology provides useful and permanent learning, practice opportunity to students, and this technology increases the motivation and engagement to the courses as well. It has been pointed out by the students that this technology should be used as a practice environment after the theoretical courses in authentic learning environments because this technology can save time and prevent cost lost in addition to avoiding risk factors. The physical environment of the classes can be improved and wireless VR goggles can be used for using this technology, more effectively and efficiently as a course support material in authentic learning environments.

Keywords: Virtual reality, head-mounted display, virtual fire drill, authentic learning environments.

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1. Introduction

Every year thousands of work accidents occur, which may result in injuries or even deaths. Constant disasters and occupational accidents are the signs that no lessons are taken from the accidents and that occupational health safety is not formed. It is important to establish a nationwide awareness of occupational health and safety in terms of the development of a healthy and reliable working environment, increasing the quality of life and also increasing productivity in enterprises and improving the quality of production. In addition, the provision of occupational health safety training is a necessity for decreasing work accidents.

Under different working conditions, employees may face many hazards. One of these hazards is the fires that can occur in the work environment. Employees who do not know what to do in the event of a fire can panic and end in calamities that result in catastrophic consequences. Doing fire drills within the scope of Occupational Health and Safety lesson can prevent the emergence of such danger before going on to a professional life. However, doing these exercises in real-life conditions can cause great danger. Therefore, the implementation of effective virtual reality (VR) applications that are close to reality, which can remove risk factors, can be seen as a solution. Considering this situation, a VR fire drill application is developed in the scope of 'Fire and Emergency Situations' course, which is given as a formal course content in the 'Occupational Health and Safety' program of Vocational School of Social Sciences of a state university in Turkey. It is aimed to evaluate the process of integrating the developed application into authentic learning environments in terms of student opinions. This VR environment is important with regards to prevent the risk factors that can be experienced in a real-life environment and it can create a realistic fire drill sense among students.

When the literary sources are analysed, there are several fire and evacuation rescue studies carried out in VR environments. A study was conducted in the Second Life campus environment to determine whether users were following the shortest route in fire evacuation training or not (Sookhanaphibarn, Choensawat, Paliyawan & Thawonmas, 2016). The effect of social influences on route selection was examined using CAVE technology in a VR fire tunnel environment (Kinateder et al., 2014a). Another study was conducted to determine the behaviour of people during a fire (risk perception, social impact, navigational skills in the fog, etc.), as well as identifying the strengths, weaknesses, opportunities and threats of VR (Kinateder et al., 2014b). Cha, Han, Lee and Choi (2012) proposed a new method for inexperienced firefighters to intuitively experience dangerous fire environments in addition to training and evaluating them. Ruppel and Schatz (2011) developed a computer game to be able to prevent the danger that could be encountered in evacuation operations in real fire environments and to be able to discover human behaviour in these situations. Smith and Ericson (2009) conducted a study with CAVE VR technology as well as using VR goggles to teach children fire hazards, increase their learning motivation and experience fire escape techniques. Gamberini, Cottone, Spagnolli, Varotto and Mantovani, (2003) conducted an empirical study to examine participants' reactions to different situations in a virtual library environment during an emergency fire. St. Julien and Shaw (2003) developed a command training environment for firefighters in the virtual environment with the Atlanta fire department. The aim was to extinguish the fire with minimum risk and minimal damage. The original aspect of our study is to evaluate the integration process of the developed VR application into authentic learning environments in terms of student opinions. However, this study is important because it is the first application of a virtual fire drill in the context of formal course content in authentic learning environments.

2. Method

2.1. Research model

This study is conducted with case study methodology. Factors related to a situation in the research (environment, individuals, behaviours and processes) have been thoroughly investigated with a

holistic approach. It is emphasised how these factors affect the situation and how they are affected by the relevant situation.

2.2. Study group

The study was conducted with five students (four male and one female) studying in the 'Occupational Health and Safety' department of a public university in Turkey. While the study group was selected, the typical sampling method which is one of the purposeful sampling methods was used.

2.3. Data collection tool

The data of the study were obtained through semi-structured interviews and observations. The data, which are gathered by semi-structured interviews, were analyzed by content analysis. Observations were made to confirm semi-structured interviews. Semi-structured interviews were voice recorded, while observations were recorded in video recording.

2.4. Virtual drill process

The Oculus Rift VR goggles were used to enhance the learning experiences of students while VR application was being developed. In addition, the Oculus Remote control device, which provides motion in the virtual environment, was used. Some of the objects in the virtual environment have been modelled with the 3DS Max program, and some objects have already been downloaded from the Internet. The placement and interaction of objects in the VR environment was programmed with the JavaScript programming language in the Unity game engine.

In the VR environment, some evaluation questions were asked primarily to measure students' basic fire knowledge. Students who finished this stage were directed to a virtual warehouse environment. Students were allowed to navigate for approximately 5 minutes in the VR environment to orient with the environment before implementation began. The environment in which the virtual fire drill would take place has been introduced. Later, students were confronted with a fire environment. They were expected to fulfil the tasks that they have to perform during a fire respectively. Potential hazards that students may encounter were shown them when they showed unexpected behaviours in the virtual drill environment. Some screenshots of the implementation are shown in Figure 1.

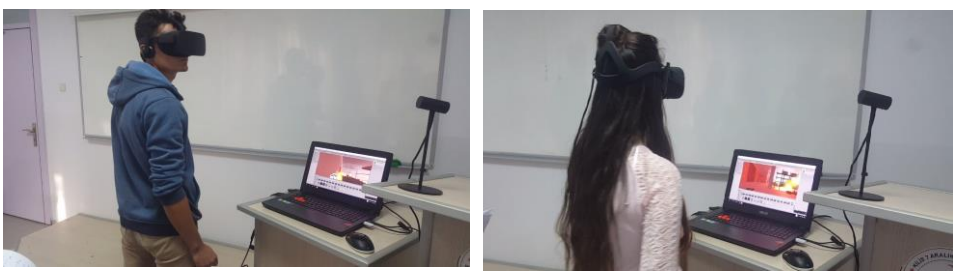

Figure 1. Implementation process

3. Findings

3.1. Semi-structured interview data

The themes and codes are shown in Table 1 that have been obtained in the light of students' opinions on how to integrate head-mounted display (HMD) VR technology into authentic learning environments and to identify the strengths and weaknesses of the application.

Table 1. Themes and codes for the integration process

Themes	Codes
Contribution to learning	Useful learning
	Retention
	Possibility of repetition
	Eliminating misconceptions
	Additional information
	Application practice
	Attendance to lesson
	Motivation
	Use requirement
Implementation method	Physical environment
	Orientation
	Implementation time
	Approach type to student
Content	Visual quality
	Design
	Reality
	Application events
	Interaction elements
Technical properties	Ergonomical
	Cable problem
	Easy of use
	Resolution
	Special production for gender
Usability	Effectiveness
	Efficiency
	Satisfaction
Limitations	First use difficulty
	Loss of balance
	Dizziness
	Nausea

The opinions of some students on how this technology can contribute to learning in the integration process into authentic learning environments are given below.

'I think it would be very useful because most of our courses are generally theoretical. We cannot understand the lesson clearly when the lecturer gives the lesson without practice. However, we see that the learning capacity of the learners is getting higher'. [S1]

'Since we cannot do it all the time in the lessons, we do it again through practice and it revives in our minds'. [S2]

'Learning by experience provides more retention than hearing and repeating'. [S3]

'It was certainly effective in eliminating the misconceptions. I have never seen fire exit doors in my life, I did not pay attention. I realized that I had known some things wrong'. [S3]

'A very effective application of theoretical knowledge to practice. You live in this virtual application. You learn by doing. People get more experience when they practice'. [S4]

'It provides attendance to the courses, because new generation loves technology. Because we love technology, we love this kind of applications too'. [S5]

Some of the student views on how this technology should be applied in the context of authentic lectures are as follows:

'First of all, the class environment should be silent. The floor must be wide'. [S2]

'I think it would be meaningless to have the practice done before the lesson. Because it's impossible to do something without knowing something'. [S2]

'I think this virtual reality application should be implemented in a smoother, more comfortable environment. The application should be done in a quiet and spacious place'. [S3]

'There must be plenty of area for the application. The student must act as he/she wishes. The student moves more comfortably because it gives confidence and comfort to the student'. [S5]

Some of the students' opinions on the application content are as follows:

'For example, the movements of people in the environment may need to reach a slightly more normal human standard'. [S1]

'It was like a factory, close to reality. The environment is real. I really felt like I was there'. [S3]

'Images and directions are beautiful, no trouble. I've had the moment. I really felt like I was pushing the buttons'. [S4]

'For example, I'm going to put out a fire with a fire extinguisher, and I can get into the fire reluctantly. You're having a hard time trying to interfere with that person. Sometimes there is a disturbance in intervention' [S4]

'…briefly it gives you the feeling of reality as if you were living that life alive'. [S5]

In order to use this technology more effectively in authentic course environments, students have expressed some considerations in terms of technical elements:

'I did not expect it to be so different and easy to use when I first started working. The use of Oculus controller was easy'. [S1]

'Ergonomically comfortable, it does not tighten. There is no excessive sound at the ear, no pressure. Good weight, light weight'. [S2]

'Technically, it may be necessary for women to have a virtual reality goggle because women have smaller heads than men. For longer hair, the earpiece may be more indented'. [S3]

'There may be entanglement in the cable during rotation. Cable should not be in place and precautions should be taken'. [S4]

The usability of HMD technology in the context of authentic lectures is expressed by the students as effectiveness, efficiency and satisfaction levels:

'It saves time and money. It will be more efficient for the learners to become better adapting to the lessons without getting tired'. [S1]

'The virtual reality experience has influenced me positively and I have been saved from routine' [S3]

'There is also no material loss in practice. If you actually get it done practically, it will be a material loss, a waste of time. There are a lot of accidents in real life, there is a problem, there is a risk'. [S4]

In the context of authentic lectures, some limitations of this technology have been expressed by students:

'The practice is unusual and odd at first. Should we go wrong, we have an anxiety that we will damage the machine. Or we were worried that we could accomplish these tasks?' [S1]

'When I started practicing for the first time, I was nauseated and I was dizzy'. [S3]

'At first, there was a jolt, dizziness, and nausea after wearing the VR google. The distress was instantaneous because it was my first experience'. [S5]

3.2. Observation data

In the VR environment, students had an experience of 10 minutes on average. Prior to implementation, they were given VR goggles and an environment presentation of about 3 minutes was made. Later, the students were put into practice. The observation times of the students in the VR environment were close to 7 minutes. In the first minute, the students clarified the vision by wearing a VR goggle. For a moment, the VR environment was shown to the students in bird's-eye view. The purpose of the application was explained to the students in the VR environment. During this time, students were allowed to watch around freely. It was aimed that the students should have knowledge about the environment. Later, the students responded to the evaluation questions directed at them by looking at the relevant question option. In the process of responding to questions, students passed this stage easily. In the following process, the students were directed into the warehouse environment where they would be performing fire drill. A fire broke out for a minute after the students walked through the warehouse. Some students experienced balance problems for a few minutes when the practice began and they struggled to stand up. After a period of time, they returned to normal movements. Students spent an average of 2 minutes and 40 seconds trying to fulfil their assigned tasks. Some students were thrilled during the activities and made sudden movements. When they fulfilled the duties that they had to do, they had realistic reactions as they did in daily life. For example, they lifted their hands when pressing the alarm button or picking up the fire extinguisher. A student struggled because of the long cable and he crashed to the table. Some students had difficulties due to some interaction problems in the application. Finally, students followed the emergency exit signs and exited from the burning warehouse. Thus, they have completed the VR fire drill application.

4. Conclusion, discussion and recommendations

According to the views of the students, this technology provides useful and permanent learning, additional information, practical opportunities for the person, helps to improve the concept and misconceptions, allows the students to repeat the learned information and increases attendance and motivation to the courses. Students expressed the necessity of using this technology in their practical courses, not in all courses. It can be interpreted as the reason for these thoughts that the students can perform the drills that they have to do after the theoretical lessons in a realistic way. In order to use this technology in the context of authentic lessons, it is necessary to provide spacious, quiet classrooms that allow students to move freely. It is important that students are oriented to the VR environment by introducing the environment to the students before the implementation. Considering student opinions, it is stated that this technology should be used as an application environment after the theoretical lectures. Students generally appreciated the VR environment in terms of visual quality and design. It is emphasised that application activities and interaction in the application should be improved a little. Technically, the resolution of the application is liked. It is an ergonomic and easy-to-use application. In general, the problem of cable has been pointed out in the implementation and this problem should be corrected. The application was found effective in terms of usability. It is seen as an efficient lesson support material because it is a useful application environment that saves time and money and can avoid risk factors that may arise in real-life situations. Some positive aspects of this technology have been highlighted, along with a number of difficulties that could be experienced due to initial use. It has been observed that students are experiencing balancing problems due to their first use of this technology. At the end of the interviews, the students stated that they had dizziness and nausea for a while. However, it has been stated by students that these difficulties were temporary, and these problems can be overcome after a certain adaptation process. Observation records show that the balance problems were disappeared a few minutes after the implementation started.

In order to use this technology more effectively as a lesson support material in authentic course environments, broad classrooms can be preferred in which appropriate application conditions are provided. The cables can be fixed with an apparatus on the top so that students can avoid cable problems, or wireless VR goggles can be produced. Mobile applications with wireless VR goggles can be developed. Application content can be improved and interactions in the environment can be corrected close to real life. Since the head physiology of men and women may differ, gender-specific VR goggles can be produced. In order to increase the use of this technology, cheaper and more usable VR technologies can be developed in authentic course environments. Virtual reality applications can be developed that will make students feel the sense of heat as a different dimension when they are practicing after their theoretical courses. After the proposed arrangements have been made for this application, the effectiveness of the application can be tested on a different and broader set of participants.

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